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Optic Flow for Enhanced Navigation and Seeker Exploitation (OFFENSE)

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TECHNOLOGY MILESTONE

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14. ABSTRACT

Modern navigation systems rely heavily on the Global Positioning System (GPS) to correct inertial measurement unit (IMU) error drifts. However, due to unreliability og GPS in certain scenarios, there is a great desire to create an inexpensive navigation solution to augment GPS based navigation. Vision-aided navigation is such a solution where information from captured imagery can supplement inexpensive on-board IMUs in bounding navigational errors that arise from IMU drifts. Optical flow information obtained from this imagery allows for the evaluation of structure-from-motion, motion-from-structure, and egomotion.

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Optic Flow For Enhanced Navigation and Seeker Exploitation (OFFENSE)

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GPS plays an important role in the guidance and navigation of small munitions and UAVs by providing positional updates which bounds the drift of the onboard inertial navigation system (INS). However, GPS is susceptible to jamming and is unreliable or unavailable in urban canyons and indoors. To mitigate GPS loss, AFRL/RWG is investigating an innovative approach based on all source adaptive fusion of any available information encompassing passive imaging data, digital elevation terrain data, IMU/GPS, altimeters, and star tracker. The approach provides continuous navigation through a non-GPS environment and yields an improved navigation in the presence of GPS. Moreover, the approach provides reduced target location error and also moving target indication.

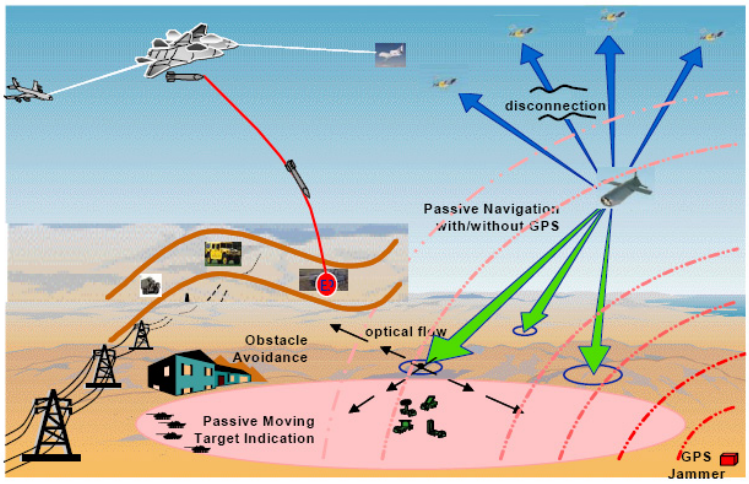

Figure 1: Video-based Navigation has a Wide Range of Applications.

There is a critical need to provide fully autonomous robust navigation capability in GPS jamming or signal interruption environment. The US Air force, Navy, and Army are keenly interested in such capability to reduce the vulnerability of GPS navigation that can be to either deliberately or unintentionally interrupted. The field of computer vision has witnessed many approaches for computing ego-motion which estimates an observer's movement (sensor or biological organism) from optical flow measurements. Optical flow is defined as "the apparent motion of the brightness patterns". The optical flow is characterized by a field of 2-D velocity vectors which are the projections of the 3-D velocity vectors of the surface points onto the image plane. The 2-D velocity vectors are derived from sequences of images which can then be used to infer the

3-D velocity of the imaging platform. Since the optical flow is a projection of a 3-D velocity vector onto a 2-D image plane, there is an inherent ambiguity in inferring the 3-D velocity. The observed optical flow therefore needs to be fused with other measurements such as depth to remove the ambiguity and to provide an estimate of the 3-D velocity vector of the imaging platform. Knowing the observer velocity vector and the last GPS position estimate will enable, in theory, navigation in non-GPS environment. Using only optical flow measurements for navigation in non-GPS environment encounters difficulties due to the variation of depth across the image field and the presence of noise in the sequence of images. Other approaches combine precision radar sensors with digital terrain elevation databases to serve as a back-up to the GPS system. Such approaches require high-level of accuracies of digital terrain data and radar sensor.

An innovative approach developed by Northrop Grumman and the AFRL Munitions Directorate, working to adaptively fuse in real-time all available navigation data such as IMU/GPS, altimeters, star tracker, passive imaging sensor, and digital elevation database. The integration of passive imaging sensors has some important advantages. Foremost, the sensors are completely passive, and can operate in an environment where the GPS signal may be difficult to receive. Secondly, the sensors are immune to disruptions in the radio spectrum. The proposed approach has been implemented and demonstrated high quality navigation performance.